Date: 17th August 2021
Our Ref No.: TJ/UT1/OUT-05

To,
Doosan Heavy Industries & Construction Co., Ltd.
Mr. Youngsoo Son– Project Manager
465 Gangnam-daero, Seocho-gu, Seoul, Korea (06611)

Contract Reference: Engineering, Procurement and Construction Contract between Nepal Water And Energy Development Company Private Limited (NWEDC) and Doosan Heavy Industries & Construction Co. Ltd for the Engineering, Procurement and Construction (EPC) for the 216 MW Hydropower Plant at Upper Trishuli -1, Nepal

Subject: Submission of Review Notes on Excavation and Initial Support Drawings of Adit No. 3 - B, Surrounding Rock Stability Calculation of Adit No. 3 - A, and Method Statement of Adit 3 Tunnel Construction – 0.

References:

1. Document No. UT1-C-000-CVL-DG-43004 (Sheet 1 to 4), Revision B dated 28st July 2021
2. Document No. UT1-C-150-CVL-DC-43002, Revision A dated 20th July 2021
3. Document No. UT1-PC-MS-019 dated 21st July 2021

Dear Sir,

Reference is made to the above Nos.1, 2 and 3, regarding excavation and initial support drawings of Adit No. 3, surrounding rock stability calculation of Adit No. 3, and method statement of Adit No. 3 tunnel construction, respectively.

Please find our comments and replies in the Review Notes (RN-0005, RN-0006, and RN-0007) enclosed herewith this letter.

Sincerely,

.....
Mr. Carsten GUNTERMANN
Project Manager (CRE)

Tractebel TRACTEBEL ENGIE Engineering GmbH

Enclosure:

1. Review Note (RN-0005), Review Note (RN-0006), Review Note (RN-0007)

UPPER TRISHULI-1 HEP (216MW)

Client	**Nepal Water and Energy Development Company Private Limited**
Owner's Engineer	**Tractebel Engineering GmbH / Jade Consult**

REVIEW NOTE

Contractor	**Doosan Heavy Industries & Construction Co., Ltd.**		
Title of the Document	Excavation and Initial Support Drawings of Adit No. 3		
Document No.	UT1-C-150-CVL-DG-43004 (Sheet 1 to 4)	Revision	B
Date of Documents	28.07.2021	Received Date	28.07.2021
Transmittal Form No.	UT1-HEP-DHI-D-0020		
Previous Review Date/Status	22.06.2021/RR	Prev. Review Note No.	RN-002
Review Note No.	**RN-0005**	**Present Review Date**	**16.08.2021**
		Present Review Status	**RR**

A: Approved AC: Approved with Comments RR: Returned for Resubmission

General Comments

1. The Contractor submitted rock support drawings for Adit No. 3, illustrating rock support measures for different support classes. In line with this, the Contractor is requested to submit necessary supporting documentation for the design of tunnel supports (i.e. calculations which prove the suitability and appropriateness of the suggested support strategy).

   Reply:For the excavation and initial support surrounding rock stability calculation to support the suggested support strategy.please see the Annex-3 UT1-C-150-CVL-DC-43002Surrounding Rock Stability Calculation of Adit No.3.

   Reply on Rev. B: The respective report has been received. It will be reviewed separately.

2. The Contractor intends to apply 6 different support classes (I, II, IIIa, IIIb, IV and V). However, the distribution of support classes with respect to rock-mass quality is not clear. As standard process, support classes are linked to a rock mass classification system (RMR, Q, etc.). The Contractor is requested to provide all baseline parameters on which the site geologist/tunnel engineer will decide on the application of suitable support class.

   Reply: six support types, which are in accordance with/following the assumed rock mass classification system, totally dividing six types, are proposed by contractor. With study on previous investigation information and with ground observation by contractor ' s geology engineer at site, the rockmass classification of adit NO.3 is assumingly divides into class II, class IIIa, class IIIb~IV (refer to longitudinal section), the excavation and support drawing provides six types support in advance to ensure all geological conditions are considered/satisfied when encountered during excavation period.

   The classification of rockmass will be jointly mapped with Q method (refer to Annex-5、Attachment 1 Tunnel Mapping format and Rockmass Classification-Q method) and determined during excavation period.

Reply on Rev. B: The drawings do correctly address all 6 support classes *"to ensure that all geological conditions are considered/satisfied when encountered during excavation period"*, quoted from above. Contradictory, the site geologist evidently informed that only classes II, IIa, IIIb and IV shall prevail in the tunnel. Such statement is unfounded. All geological conditions must be expected, even this may be unlikely and the respective stability calculations must include all classes.

The drawings do not answer the question "what Q-value refers to which support class?". The Q-value ranges shall be specified for each class.

3. The Contractor is requested to provide a Method Statement for Tunnel Excavation which is applicable for the excavation of all tunnels in the project. The Method Statement shall contain information regarding (i) equipment, (ii) personnel, (iii) procedures (used rock-mass classification system, procedures regarding the application of support measures, details regarding the sequence of excavation & support installation, etc.), and (iv) health & safety plan.

Reply: See the Annex-7 METHOD STATEMENT of ADIT 3.

Reply on Rev. B: The respective report has been received. It will be reviewed separately.

4. The Contractor is requested to submit the overall layout of Adit No. 3 location including the chainage where Adit No.3 meets the Headrace Tunnel.

Reply: Regarding the overall layout of Adit No. 3, please refer to sheet 1, GENERAL PLAN LAYOUT OF ADIT NO.3, which shows the chainage of intersection of adit tunnel 3 and headrace tunnel, H+6,586.326m based on the present design.See the Annex-2 -1UT1-C-150-CVL-DG-43003_Layout Drawing of No.3 Construction Adit.

Reply on Rev. B: Noted.

Drawing UT1-C-150-CVL-DG-43004 Rev. B, Sheet 1 of 4

5. Note No. 1 mentions that the set of drawings refers to the "*initial support*". The Contractor is requested to clarify and explain what is understood as "initial support".

Reply: as per EM 1110-2-2901 TUNNELS AND SHAFTS IN ROCK, Chapter 7, Design of Initial Support, 7-1. Design of Initial Ground Support, " a. Initial ground support is installed shortly after excavation in order to make the underground opening safe until permanent support is installed. The initial ground support may also function as the permanent ground support or as a part of the permanent ground support system" .

as per EM 1110-2-2901, Chapter 7, 5-4. Initial Ground Support "Initial ground support may consist of steel ribs, lattice girders, shotcrete, rock dowels, steel mesh, and mine straps. The main purposes served by these support elements include stabilizing and preserving the tunnel after excavation and providing worker safety……After installation of initial ground support, no other additional support may be required. In this case, the initial support will also fulfill the role of final support. In other cases, additional support, such as a cast-in-place concrete lining, may be installed."

To class I~IIIb, shotcrete, rock dowels are designed as the initial and final support, to class IV~V, if encountered, shotcrete, rock dowels, steel ribs, lattice girders are designed as the initial support, cast-in-place concrete lining is considered as final support, the initial and the final ground support then comprise a composite support system.

Reply on Rev. B: Noted.

6. Note No. 3 refers to "*a loose block which has a major influence on the slope stability*". Further details of the slope conditions in the portal area are missing. Contractor is requested to carry out a slope status assessment with the input of an Engineering Geologist and submit respective supporting documentation.

Reply: the purpose of this note is to remind subcontractor to avoid loose material falling down affecting construction activities by removing or anchoring the surface loose material, if any, fall down. The slope of portal area was inspected by subcontractor when selecting the location of portal.

A joint inspection regarding loose material/rock to assess status of slope by Employer ' s engineer, contractor, subcontractor prior to portal excavation is proposed.

Reply on Rev. B: A slope status assessment has not been submitted. Instead, some geological information is included in the drawing, which is

- Indication of the rock type "gneiss", approximately 80 m above the tunnel. Furthermore, "interbedded mica shist and quartz schist" is shown close to the tunnel. No lithological boundary is shown. Consequently, one cannot identify the rock type that is prevailing at the tunnel.
- The boundary of moderately to slightly weather rock is indicated at a depth of 40-50 m below ground surface. Such great depth is unlikely in the prevailing rock types in the Upper Himalayans and needs justification in the requested slope status assessment.
- Three discontinuity sets are indicated in the drawing: foliation 290-340/15-30, joint set J16 040/28, joint set J15 280/60. A proper discontinuity analyses is required for the portal slope.
- No colluvium or other soil is indicated.

Rock classes are estimated to be:

- from the portal to Ch. 48.6 classes IIIb and IV (= 16% of tunnel length), while Ch. 48.6 is the boundary of the moderately to slightly weather rock (see also the note above that refers to this estimated boundary). There is no geological justification to put this boundary between moderately to slightly weathered rock.
- from Ch. 48.6 to Ch. 199.8 class IIIa (= 49% of tunnel length)
- from Ch. 199.8 to the junction with the HRT, class II (= 35% of tunnel length)

It shall be noted on the drawing that these estimates are purely speculative, and all rock classes may be encountered.

The contractor shall provide a slope assessment report that may be very helpful to optimize the portal design as will be indicated further below. The requested report shall follow the requirements of the Technical Specifications Sub-clause 14.3.1. Geological Mapping.

7. Note No. 6 mentions that the span at tunnel intersections and "*turning adit*" (passing bays) is large. Intersections and niches constitute require support modifications based on their geometrical features (i.e. span, type of junction, and stretch length). Rock support measures shall adapt to these enlarged sections (i.e. longer bolts due to larger span, modified bolt patterns, shotcrete thickness, etc.). Hence, Contractor is requested to provide information regarding specific support measures for tunnel intersections and passing bays (niches).

Reply: Support measures at tunnel intersection already be strengthened with two rows longer rock bolt. Regarding to the turning adit will Confirm the support form through the geological sketch of the geological engineer.

Reply on Rev. B: The support measures are required to be designed for junctions and turning bays. When using the Q-system, the factor J_n is tripled for junctions, see NGI (2015: Table 2). With the newly developed Q-value, which is now a third of the original, stability calculations need to be conducted to determine the required support. Contractor is requested to conduct such design. Note that for the portal design the factor J_n is doubled.

Reference:

NGI (2015): Using the Q-System – Rock Mass Classification and Support Design.- Norwegian Geotechnical Institute. Downloadable at www.ngi.no

Drawing UT1-C-150-CVL-DG-43004 Rev. B, Sheet 2 of 4

8. Sheet 2 of 4 shows a detail (Detail A) regarding the slope support above tunnel portal. As mentioned before, further information (i.e. overburden, rock line, major joint sets, loose blocks, etc.) regarding the geological conditions of the portal slope shall be provided in order to assess the suitability of the suggested support measures.

Reply: the geological information was showed in Rev.B, please refer to the Detail A of Annex-2 -2UT1-C-150-CVL-DG-43004_EXCAVATION AND INITIAL SUPPORT DRAWINGS.

Reply on Rev. B: There is no geological information provided on this drawing and on drawing UT1-C-150-CVL-DG-43004 Rev. B, Sheet 1 of 4, the information is unreliable as detailed above.

Nevertheless, the topography, namely the overall slope angle of 45° in the slope above the portal and the steepening of the slope at the portal to 58°, as shown in the figure below provide indications on the geological situation. Such steep slope angle (58°) clearly indicate that the portal area consist of *in-situ* rock, presumably covered with colluvium at its base. This situation is highlighted in the following sketch.

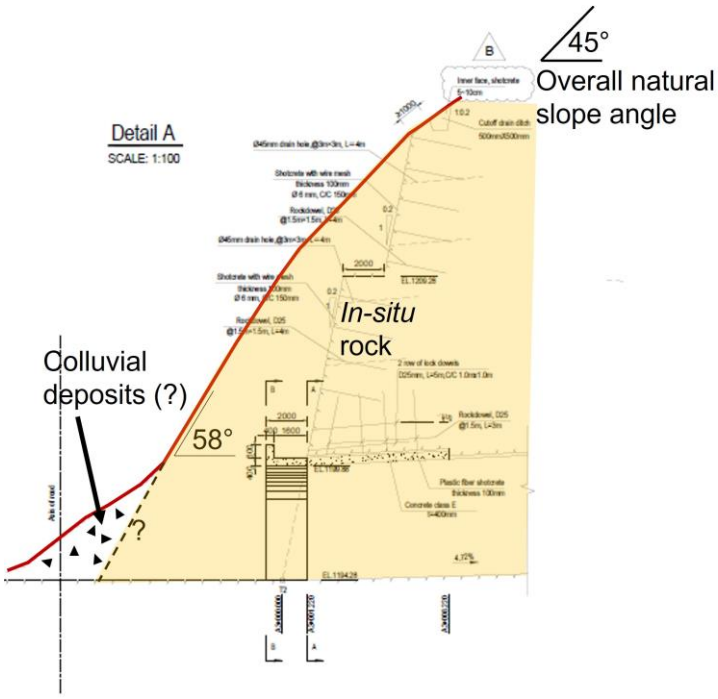

Figure: Estimated geological situation at the portal of Adit No. 3, derived from the topography and geological consideration.

Unfortunately, no reliable information from the site is available that allows confirmation of this estimate. In case this situation can be confirmed with the requested geological site assessment,

significant savings may be achieved. The portal can be shifted further out and the 25 m high excavation in rock gets reduced to less than 10 m.

The steep slope does not only indicate in-situ rock, but also rock of reasonable quality, so that the planned tunnel lining of reinforced concrete can be omitted. The Contractor shall submit a geological site assessment of the portal area so that relevant decisions can be made.

The Contractor shall justify his design of the False Tunnel Structure built by reinforced concrete. This can be done in the design calculation report of the tunnel. This shall also include the load assumptions.

The reinforced concrete structure in the tunnel at the portal is for a temporary access tunnel generally not considered necessary. The 6 m high portal slope should be cut vertically (portal and spiling area only). Only in Class IV and V is an inclined portal slope of advantage. The spacing of the spiles (= the dowels, 5 m long) around the crown of the tunnel and in the upper side walls shall be 0.4 m, only. It shall be noted that a second row of spiles may be required in class IV or V with staggered arrangement to the first row, placed 0.3 m outward of the first row. The lookout angle of the spiles shall be 4° at a maximum. The spiles shall stick out by 0.3 m from the shotcrete that is applied at the vertical portal slope. A lattice girder, or equivalent steel rib shall be included that is placed underneath the spiles. The sticking out rebars need then be embedded by 300 mm fibre reinforced shotcrete. The lattice girder needs also to be embedded in shotcrete of respective thickness. This arrangement produces a load carrying arch (= shotcrete arch in roof and upper side wall), which is connected with the lattice girder directly beneath it. Furthermore, the spiles are connected to this arch and can carry load and act as cantilever when the tunnel is getting opened.

Further lattice girder(s) may be required when advancing, depending on rock mass quality.

9. Detail A also shows a drainage ditch at the top of the protected slope area. Will the drainage ditch excavation in rock or soil? Is there any pavement foreseen (e.g. shotcrete, concrete, stone masonry) for this drainage ditch?

Reply: the drainage ditch will be excavated in rock as per present geological information. Shotcrete is scheduled to be applied as pavement, please refer to the Detail A of Annex-2 -2UT1-C-150-CVL-DG-43004_EXCAVATION AND INITIAL SUPPORT DRAWINGS.

Reply on Rev. B: A perimeter drain in rock is usually very difficult to construct and is considered not necessary over the entire perimeter of this temporary excavation, but only above the tunnel. A simple and easy-to-construct drain is sketched below.

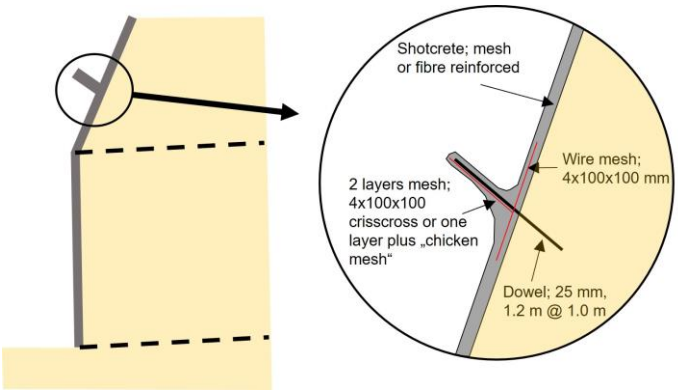
Shotcrete; mesh or fibre reinforced
Wire mesh; 4x100x100 mm
2 layers mesh; 4x100x100 crisscross or one layer plus „chicken mesh“
Dowel; 25 mm, 1.2 m @ 1.0 m

Figure 2: Simplified sketch of cross section through a tunnel portal with drainage channel above the portal. A drainage channel is constructed above a tunnel portal by placing steel mesh with “chicken mesh” onto already placed shotcrete on the slope. This is then covered with shotcrete. The drain is inclined towards one side.

The Contractor shall consider this solution and modify the drawing accordingly.

10. Note No. 2 indicates that shotcrete with "*cylinder strength of only 21 MPa (28 days)*" will be applied. Contractor is requested to submit a list of approved shotcrete mixes for the project. Moreover, a shotcrete strength of only 21 MPa is considered as rather low for underground works. For underground works, and especially when it comes to permanent support, it is rather common to apply at least C30, with a cylinder strength of 30 MPa (28 days).

Reply:1)、 Regarding strength of shotcrete, requirement of contract is abstracted as below, which says 21MPa shall be applied to general shotcrete.Besides through calculation, we know that 21MP fully meets the requirements of bearing capacity,see the Annex-3 UT1-C-150-CVL-DC-43002Surrounding Rock Stability Calculation of Adit No.3.

Reply on Rev. B: Noted.

2)、 If OE require the concrete strength of 30MPa, which will improve the tunnel mixing strength standard. It will be considered as a variation and we will initiate the contract change procedure.

Reply on Rev. B: Noted.

11. Note 4 describes that concrete class E refers to a cylinder strength of 24 MPa (28 days). Contractor is requested to submit a list of approved concrete mixes for the Project.

Reply: See the Annex-4Cylindrical concrete mix ratio.

Reply on Rev. B: The respective report has been received. It will be reviewed separately.

Drawing UT1-C-150-CVL-DG-43004 Rev. B, Sheet 3 of 4

12. Sheet 3 of 4 provides details of the rock dowels. The diameter of the rock dowel and the diameter of the borehole should be indicated in these details, as well.

Reply: The mentioned information we already added in the updated drawing,see the DETAIL ROCKDOWL OF Annex-2 -3UT1-C-150-CVL-DG-43005_EXCAVATION AND INITIAL SUPPORT DRAWINGS .

Reply on Rev. B: Information ref dowels is noted. The water/cement ratio of 0.4 for the grout shall be indicated as per Technical Specifications Sub-clause 13.3.4.1.. Furthermore, the Contractor is reminded that the Technical Specifications Clause 14.3.2.G require a 38 mm diameter borehole and not a 42 mm diameter borehole as shown in the drawing. Such large diameter requires 22% more grout for the bolts, which is significant considering the large number of 25 mm diameter dowels installed in the project.

Drawing UT1-C-150-CVL-DG-43004 Rev. B, Sheet 4 of 4

13. As already mentioned, the rock-support baseline criteria are not clear. Contractor shall relate proposed support measures to a rock-mass classification system, for each support class.

Reply: The support type is based on each rockmass classifications, which are assumed prior to actual excavation and will be mapped and determined during excavation period.

Reply on Rev. B: The Contractor is requested to provide the Q-value range for each rock class on the drawing. Class I requires not only spot bolting as correctly indicated, but also shotcrete, where necessary.

A class II rock is generally characterized by blocky, jointed rock of reasonable quality. Nevertheless, due to the high potential of wedge failure in the roof and from the upper side walls, systematic rock bolting should be generally in class II rock.

Class IIIa shows 80 mm shotcrete and class IIIb 100 mm shotcrete, which is in practice (and in theory) virtually no difference.

The drawing shall also indicate

- The round length for each class
- The allowable unsupported or partially supported span for each class. This shall indicate – in terms of distance from the tunnel face - when shotcrete or dowels must be installed. The time of installation of the lean concrete slab in the tunnel floor shall also be indicated.

14. The Contractor obviously intends to apply plastic fibres as reinforcement for the shotcrete. It is strongly recommended to use steel fibres, instead. Typically, steel fibres are globally used as reinforcement for shotcrete. Shotcrete reinforced with steel fibres in comparison to plastic fibres provides higher compressive strength (peak/residual), as well as flexural strength. Therefore, it is considered as first choice for the support of underground structures.

Reply: According to 13.1.1-7 in Appendix 13Part C of the Contract Documents, plastic fiber or steel fiber can be used in shotcrete. The contractor therefore has the right to choose which material to use. Moreover, in the original tender drawings, all the plastic fibers shotcrete is shown, and the Contractor also considers the Plastic fibers shotcrete in the tender stage.

The design adopted by the Contractor is in accordance with the Contract and shall be subject to the Contract Variation if the Engineer requires steel fibre to be specified.

Reply on Rev. B: Practical experience with plastic (polypropylene) fibre reinforced shotcrete has shown significant disadvantages in tunnelling, when compared to steel fibres. The density of the fibres is 0.910 kg/m^3 (see testing report on fibres, Annex-6), i.e. it floats on water. In case water is encountered in tunnels - as one must expect in the tunnels and the PH at UT1 – the fibres are washed out from the shotcrete and transported by water. The plastic fibres frequently lead to clogging of drainage systems and failure of pumps.

Furthermore, the Contractor is reminded that the Technical Specification Sub-clause 13.1.5.E request

- Reinforcing fiber content amount shall be controlled about mix to satisfy the design flexural strength and flexural toughness. The content amount that actually placed on the wall shall be not less than 8kgf/m^3 in the case of plastic fiber (not less than 40kgf/m^3 in the case of steel fiber).

This means that 8 kg/m3 shall be “actually placed on the wall”. As the density of the fibres is low as compared to the mix, the amount of rebounded plastic fibres will be in practice very high (when comparing this to rebounded steel fibres). Such requirement points to a much higher plastic fibre content in the mix than the 8 kg/m3. This Contractor shall consider this.

As per contract, the Contractor is required to follow standard and modern methods in construction. Regarding shotcrete, the Contractor is reminded to follow latest technologies summarized in Geomechanics and Tunnelling (2021).

Reference:

Geomechanics and Tunnelling (2021): Fibre reinforced tunnel linings – design and construction experience. - Austrian Society of Geomechanics, August 2021, ISSN 1865-7362, pp. 218-400.

15. Contractor is requested to provide information regarding steel fibre content of the shotcrete.

Reply: We will provide qualified plastic fiber information and mix shotcrete according to the amount of plastic fiber specified in the contract. Add 8KG of plastic fiber per cubic metre of concrete. See the Annex-6 REVIEW ON MATERIAL TEST REPORT FOR UT1 HEP 216MW.

Reply on Rev. B: Noted.

16. The sections indicate an invert slab for each support class. Contractor is requested to provide information regarding the material foreseen for the invert slab.

Reply: Because the ADIT 3# tunnel is a temporary tunnel, there is no concrete at invert slab,but for However, for Class 4 and Class 5 surrounding rocks, we will use lean concrete to strengthen the steel support. The grade of concrete is 12MPa concrete according to the contract requirements.

Reply on Rev. B: An unreinforced lean concrete slab of 200 mm cannot take moments and hence does not noteworthy contribute to strengthen the steel support. Reinforcement (mesh) is required.

17. Sections for Rock Class IV and V and the section for forepoling indicate "*concrete*" as inner lining additionally to the shotcrete. The Contractor is requested to provide further details regarding the purpose and properties of the proposed "*concrete*" (e.g. concrete strength, reinforcement if required, etc.). Furthermore, the Contractor is requested to clarify the method of application (i.e. cast in place concrete with formwork or shotcrete).

Reply: Aim of proposed concrete lining is to provide additional support to the poor condition rockmass, if encountered and applied, additional drawings about concrete outline and reinforcement will be prepared and provided, the properties of concrete and reinforcement will be provided in the drawing.Regarding the method of application refer to Annex-7 METHOD STATEMENT of ADIT 3.

Reply on Rev. B: The Contractor shall consider replacing the reinforced concrete with fibre reinforced shotcrete of adequate thickness as this is a temporary tunnel and concrete lining hampers progress.

DISCLAIMER

Any approval will not release the Contractor from any of his obligations under the Contract.

Dr. Ulrich Glawe

(Signature)